Fixed-Price Development Contracts: A Historical Perspective

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The Center for Public Policy and Private Enterprise at the University of Maryland's School of Public Policy provides the strategic linkage between the public and private sector to develop and improve solutions to increasingly complex problems associated with the delivery of public services—a responsibility increasingly shared by both sectors. Operating at the nexus of public and private interests, the Center researches, develops, and promotes best practices; develops policy recommendations; and strives to influence senior decision-makers toward improved government and industry results.

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Executive Summary

The Department of Defense (DoD) continues to struggle to contain the costs of its weapons programs. In fact, there are indications that over the past few years, cost growth has actually increased. In 2003, the Government Accountability Office (GAO) found that the costs of major development acquisition programs (MDAPs) exceeded initial estimates by a combined total of $186 billion. By 2007, this figure increased to $302 billion, and by 2011, MDAPs exceeded their initial estimates by $402 billion (GAO, 2011). Moreover, the cost of DoD programs in absolute terms has also increased.

In its recent effort to reduce the costs of military acquisitions, the Obama administration mandated that the DoD increase the use of fixed-price contracts. However, the enduring problem of increasing costs suggests multiple, systemic failures occurring within the acquisition process. Unfortunately, the tendency to promote simplistic (and often ineffective) remedies over substantive reform often guides policy decisions. The fact is that the DoD already spends the vast majority of its acquisition funds on fixed-price contracts for specified quantities of products, usually with good results: quality products are furnished to the DoD at agreed-upon prices. When it comes to major development programs, there may be a good reason that the DoD has come to rely more on cost-reimbursement (as opposed to fixed-price) contracts.

Unlike other DoD programs, MDAPs are often associated with a high level of uncertainty. This uncertainty may stem from a variety of sources, including the use of immature technologies or budgetary challenges or the need to make changes as the design matures. Cost-reimbursement contracts are more appropriate when there are system performance uncertainties or when there is a likelihood that changes will be required, making it difficult to project accurate cost estimates with sufficient accuracy to allow for fixed-price contracts.

Because many of the DoD's systems are technologically advanced, complex, and, in some cases, unprecedented (i.e., there are no prior examples on which to base development), requirements, quality dimensions, and performance specifications often evolve over time. As one might expect,

it can also be difficult to verify whether or not the contractor has fulfilled its obligations, given the lack of detailed specifications contained in the contract. In short, incomplete information results in higher risk.

In its effort to control cost growth, the DoD periodically embraces fixed-price contracts in order to shift more of the responsibility and risk to the contractor. In the 1950s, the DoD's heavy use of cost-reimbursement contracts resulted in significant cost growth, which led to the introduction of total package procurement (TPP), a strategy under which single, fixed-price contracts were used to cover research, development, production, and, often, support. TPP was conceived by the Air Force in the 1960s. Under TPP, "all anticipated development, production, and as much support as is feasible of a system throughout its anticipated life is to be procured as one total package and incorporated into one contract containing price and performance commitments at the outset of the acquisition phase of a system procurement" (Logistics Management Institute, 1967, p. 3). However, inaccurate cost estimates, which were often based on uncertainties introduced by overly optimistic technology assessments, led contractors to chronically underbid. In 1988, Congress reacted to the issue, passing Section 8118 of the Defense Appropriations Act, which prohibited the DoD from awarding fixed-price contracts in excess of $10 million for development of major systems or subsystems.

The early 2000s saw continued support for cost-reimbursement contracts. The Defense Federal Acquisition Regulation Supplement (DFARS, 2012) restricted the DoD's use of fixed-price contracts for development programs by adding two conditions: (1) the level of program risk permits realistic pricing and (2) the use of a fixed-price contract permits an equitable and sensible allocation of program risk between the government and the contractor. The DFARS also states that for development efforts, cost-reimbursement contracts are preferred.

Agency theory, transaction cost theory (TCT), and incomplete contract theory provide a basis for understanding the advantages and disadvantages of cost-reimbursement and fixed-price contracts from the perspective of the contractor and the customer. According to agency theory, whenever one party (principal) depends on the action of another (agent) in a particular domain, a principal–agent relationship arises. It can be difficult to ensure that the agent acts effectively on behalf of

the principal because (1) there is an inherent difference in the principal's and agent's interests (value conflict) and (2) it is difficult or expensive for the principal to monitor the agent's actions; as a result, the agent may have more insight into the real state of the work (information asymmetry). To benefit from the terms of a contract, the DoD's personnel must have access to all of the required information when negotiating contracts with outside providers; however, when it comes to the long-term development of major systems, this is commonly not the case. Consequently, the use of a fixed-price contract is generally not appropriate.

If agency theory argues against the use of fixed-price development contracts, TCT suggests that there are potential benefits associated with this contract type. A transaction cost is "any activity which is engaged in to satisfy each party to an exchange that the value given and received is in accord with his or her expectations" (Ouchi, 1980, p. 130). TCT asserts that transactions between individuals (or organizations) are not cost free. By using fixed-price contracts, the DoD can eliminate some of the transaction costs normally incurred after the contract is awarded. For example, under a cost-reimbursement contract arrangement, the DoD must determine what constitutes an allowable expense. Under a fixed-price contract, the costs associated with making such a determination are eliminated. However, this advantage is less apparent if numerous changes are made to the fixed-price contract (since each change creates an additional transaction). As previously stated, weapons programs are often initiated with incomplete information, and there are generally many changes driven by evolving technology and requirements.

Creating a contract that is truly comprehensive is unrealistic; that is, few contracts can precisely define each party's obligations in all potential scenarios that may arise. Even when it is possible to do so, the transaction costs involved often make it impractical. Broadly speaking, incomplete contract theory generally does not support the use of fixed-price contracts for weapons system development programs. Because initial performance requirements are often unstable, the ambiguity in the contract may enable the contractor to technically meet a requirement according to the letter of the contract (or its interpretation of the contract) but fail to meet its intent as envisioned by the DoD. In addition, because programs usually take between 10 and 20 years to develop, programs may undergo significant change as a result of emerging technology.

In this report, we examine three DoD aircraft acquisitions that relied on fixed-price contracts to highlight the various risks associated with fixed-price contracting. First, we examine the C-5 Galaxy.

In an effort to incentivize contractors to minimize program costs, Secretary of Defense Robert McNamara introduced TPP in the mid-1960s to acquire the C-5, one of the largest military aircraft ever produced. As its name suggests, TPP incorporates into a single contract all development and production (and, often, support) costs. In addition, the contract would include precise price and performance expectations. The C-5 contract was negotiated, using this strategy, with a fixed-price-plus-incentive contract. Lockheed submitted the lowest bid of $1.9 billion and was eventually awarded the contract. In 1968, the Air Force projected that the program might exceed initial estimates by more than $2 billion. Moreover, there is some indication that the Air Force may have attempted to conceal the overruns from Congress. In late 1968, the Air Force realized that Lockheed was on the verge of bankruptcy. In 1969, realizing that it would have little recourse should Lockheed's situation worsen, the Air Force took delivery of the first C-5A, leaving many of the acknowledged deficiencies unresolved. In 1971, the Air Force replaced the existing contract with a cost-minus-fixed-fee contract, under the condition that Lockheed absorb a $200 million loss, which was more than half of the firm's net worth.

Next, we examine the F-111, a multipurpose tactical fighter-bomber capable of supersonic speeds. By the late 1950s, both the Air Force and the Navy were considering replacing a number of their ageing fighters. Although their needs differed considerably, Secretary McNamara insisted that the Navy and Air Force work together to develop joint requirements to the extent possible. In November 1962, a fixed-price-incentive-contract was awarded to General Dynamics. However, despite Secretary McNamara's proclamation that the development and production of a common aircraft would save as much as a billion dollars, costs increased dramatically over the duration of the program. The early development of the F-111 proved problematic and costly. By 1972, the development cost estimate more than tripled, to $1.675 billion, while the production estimate increased by more than $3 billion, to $5.334 billion. The first flight of the F-111A took place in December 1964, and the first production models were delivered to the Air Force in 1967. Meanwhile, the F-111B was canceled because it was not meeting the Navy's expectations.

Lastly, we examine the A-12 Avenger II. The objective of this program was to incorporate advanced stealth technology into the development of medium-attack aircraft with long ranges, high payloads, and a very low visibility profile. The Navy initially planned to buy 620 A-12s, and the Marine Corps planned to purchase an additional 238 planes. The Air Force also considered buying 400 A-12s. In January 1988, a team consisting of General Dynamics and McDonnell Douglas personnel was awarded a full-scale, fixed-price-incentive-contract, with a target price of $4.38 billion. From the beginning, the development process was troubled by a series of significant technical and engineering problems. In the early 1990s, as the development process evolved, the contractor team, McDonnell Douglas and General Dynamics, admitted that the project faced serious engineering problems and that some performance expectations could not be met. Secretary of Defense Dick Cheney directed the Navy secretary "to show cause" by January 4, 1991, as to why the DoD should not terminate the program (Congressional Research Service [CRS], 1991). The Navy, in turn, required that the contractors respond to Secretary Cheney's demand and notified them that the contract might be terminated unless satisfactory conditions were obtained by January 2, 1991. The contractor team submitted a new certified program claim, requesting a $1.4 billion increase in the target price, and stated that they could not meet the technical specifications and deliver the aircrafts in accordance with the terms of the original contract. In January 1991, Secretary Cheney directed the Navy to terminate the A-12 program.

Based on the theoretical considerations and the examples presented in this report, we believe that fixed-price contracts are not well-suited to major weapons system development programs. This is not to say that, as a rule, fixed-price contracts should never be used in development programs but that their use will not correct, or compensate for, systemic defense acquisition challenges (e.g., inaccurate cost estimates, over-optimism, lack of technical knowledge). Flexibility with regard to costs, schedule, and performance should be built into a contract so that trade-offs can be made as development progresses. Cost-reimbursement contracts are more appropriate in this regard. Yet, at this moment, fixed-price contracts are being used to acquire MDAPs throughout the DoD.

As the U.S. economy, still reeling from the recession of 2008, continues along the path to recovery, lawmakers are searching for ways to cut spending in order to reduce the country's $16

trillion debt. The DoD, which consumes the second largest portion of government revenue after entitlements, will likely see significant cuts in coming years. In light of these budgetary constraints and widespread security challenges, the DoD will need to rethink how it uses its dwindling resources; in simple terms, it must be able to do more with less. What worked in the past may not work in the coming years. The DoD must initiate bold reforms to bring increasing costs under control. In the grand scheme of things, the back and forth over contract type is a distraction from the systemic problems that we can no longer afford to ignore.

I. Introduction

The Department of Defense (DoD) continues to struggle to contain the costs of its weapons programs. Yet, the underlying causes of cost growth—over-optimism, estimating errors, unrecognized technical issues, requirements creep, and budget, quantity, and schedule changes—have been understood and elaborated on for decades. In 1982, an unnamed witness at a House Armed Services Committee meeting declared that "Enough material has been written on the subject of cost growth during the past 10 years to fill a Minuteman silo"[1] (Calcutt, 1993, p. 1). Thirty years later, the causes and magnitude of program cost overruns remain relatively unchanged—as confirmed by three or four more silos worth of studies and analyses.

A 2006 Rand report analyzed selected acquisition reports (SARs) on 46 completed weapons systems programs over the course of three decades, between 1970 and 2000 (Arena, Leonard, Murray, & Younossi, 2006). The study compared the costs at major acquisition decision milestones (MS) with initial cost estimates. It found that the average adjusted total cost for a completed program grew (i.e., exceeded the initial estimate) by 46% between the system development and demo milestone decision (MS B) and the production and deployment milestone decision (MS C). The report then examined the extent of cost growth by decade and concluded that among completed and ongoing programs, each decade saw similar increases in development costs.

In fact, there are indications that over the past few years, overall program cost growth has actually increased. Periodically, the Government Accountability Office (GAO) analyzes cost growth occurring within the DoD's major defense acquisition programs (MDAPs).[2] In 2003, the GAO found that program costs exceeded initial estimates by a combined

[1] A Minuteman silo is approximately 10 ft. wide and 70 ft. deep.

[2] An MDAP is an acquisition program that requires an eventual total expenditure for research, development, test, and evaluation (RDT&E) of more than $365 million in fiscal year (FY) 2000 constant dollars or more than $2.190 billion in procurement in FY2000 constant dollars (Major Defense Acquisition Program Defined, § 2430).

total of $186 billion. By 2007, this figure increased to $302 billion, and by 2011, MDAPs exceeded their initial estimates by $402 billion[3] (GAO, 2009a; GAO, 2011).

Perhaps an even greater challenge is that the unit cost of DoD programs in absolute terms has also increased rapidly. For example, the unit cost of high-performance aircraft programs has grown at an exponential rate over time (see Figure 1). In 1984, Norman Augustine made an intriguing, if not alarming, prediction:

> In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3½ days each per week except for leap year, when it will be made available to the Marines for the extra day. (p. 12)

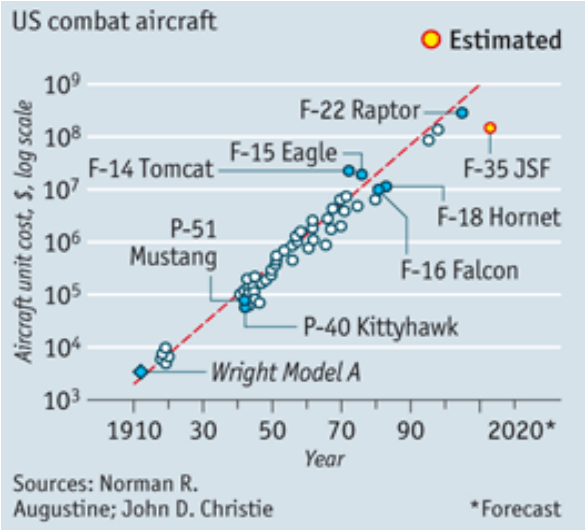


Figure 1. Augustine's 16th Law
("Defence Spending In A Time Of Austerity," 2010).

Recent estimates put the total cost (i.e., production, operations, and support costs in then-year dollars) of the F-35 Joint Strike Fighter at $1.5 trillion, making it one of the most costly DoD programs in history.

[3] Figures are in 2010 constant dollars.

Despite decades of attempted reforms, the DoD has struggled to acquire weapon systems at reasonable cost. The Obama administration, for its part, has pointed to the DoD's increased reliance on contractors as a source of cost growth. Indeed, the DoD has steadily increased contractor spending over the past decade, from just under $150 billion in 2000 to approximately $400 billion in 2008 (Weigelt, 2012). In 2009, the Obama administration mandated that the DoD increase the use of fixed-price contracts in order to reduce the costs of military acquisitions. At first glance, the rationale seems obvious: the use of fixed-price contracts reduces costs by ensuring that the DoD pays its contractors no more than the agreed-upon price.

However, the historic problem of increasing costs suggests multiple, systemic failures occuring within the acquisition process (including frequent program changes introduced by both the DoD and Congress). Moreover, the growing technical complexity of projects can make managing cost growth more challenging. Recent surveys indicate that the cost of complex, commercial-sector "megaprojects" increases by an average of 30% over initial estimates (Flaherty, 2012). Unfortunately, the tendency to promote simplistic (and often ineffective) remedies over substantive reform often guides policy decisions. The DoD already spends the vast majority of its acquisition funds on fixed-price production contracts for specified quantities of products, usually with good results: quality products are furnished to the DoD at agreed-upon prices. In other words, there may be a good reason that the DoD has come to rely more on cost-reimbursement (as opposed to fixed-price) contracts for MDAP research and development.

Report Road Map

This report adopts a historical perspective to analyze the effectiveness of fixed-price contracts in acquiring MDAPs. We begin with a brief survey of the different contract types employed by the DoD, describing their basic characteristics. Second, we examine the theoretical basis for the various contract types as well as the contexts within which they can provide the most benefit to the parties involved. In Section IV, we examine three DoD aircraft acquisitions that relied on fixed-price contracts: the C-5 Galaxy, the F-111

Aardvark, and the A-12 Avenger II. We also provide a brief overview of the F-117 Nighthawk program, which used a cost-reimbursement contract during the development phase. In Section V, we present the lessons learned and discuss some of the common challenges associated with fixed-price contracting. Also in Section V, we offer our recommendations and concluding remarks.

II. Background

In general, contracts vary across two important dimensions: (1) the degree and timing of the responsibility assumed by the contractor for the costs of program performance and (2) the amount and nature of the incentive offered to the contractor for achieving or exceeding specified standards or goals. The DoD typically relies on two contract types to acquire weapons systems: fixed-price and cost-reimbursement contracts (see Table 1).

Contract Type	Government	Contractor	Who assumes the majority of the risk?
Fixed-price	Pays fixed price even if actual total cost of product exceeds the contract price. May also pay an award or incentive fee related to performance.	Provides an acceptable deliverable at the time, place, and price specified in the contract.	Contractor
Cost-reimbursement	Pays contractor's allowable costs incurred, to the extent prescribed by the contract. Also may pay a fee, which may be related to performance. Contracts include an estimated total cost for purposes of obligating funds and a ceiling that the contractor exceeds at its own risk (unless approved by the contracting officer). Government is not guaranteed a completed end item or service within the estimated cost.	Makes good faith effort to meet government's needs within the estimated cost.	Government

Table 1. Fixed-Price and Cost-Reimbursement Contracts
(GAO, 2009b)

Fixed-price contracts specify the amount that the contractor will receive for fulfilling the terms of the contract. The price the government pays will only change if the contract itself is revised. This type of contract shifts most of the risk to the contractors, since they assume the responsibility for all costs and the resulting profit or loss. It also provides the greatest incentive for the contractor to perform effectively while maximizing their profits (by controlling their costs). Moreover, these contracts reduce the administrative burden on both contracting parties. In general, fixed-price contracts should be used "when the

risk involved is minimal or can be predicted with an accepted degree of certainty" (FAR 16.202). In contrast, cost-reimbursement contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract up to a predetermined cost ceiling (FAR 16.301). Under this type of contract, the contractor has minimal responsibility for the performance costs. By their nature, cost-reimbursement contracts have a higher administrative burden because the contractor must have a compliant cost accounting system and costs must be audited by the government to ensure their validity.

Both of these contract types can be combined with incentives and fees to create a variety of different incentive structures. For example, fixed-price incentive contracts can include a target cost, a target profit, a price ceiling (but not a profit ceiling or floor), and a profit adjustment formula. They can also include sharing formulas, which reward contractors with a percentage of the savings if they are able to deliver the final product below the agreed-upon target price. On the cost-reimbursement side, a cost-plus-fixed-fee contract pays contractors for all of its allowable incurred expenses plus additional payment in the form of profit, but these contracts can also be structured with incentives and/or award fees.

Each contract type provides a different combination of performance and risk to the government. The objective of selecting an appropriate contract type is to reasonably and fairly allocate the risk between the government and the contractor while providing an incentive to the contractor for efficient and economical performance.

Choosing the appropriate contract type to acquire MDAPs can be challenging. Unlike other DoD programs, MDAPs are often associated with a high level of uncertainty. Peck and Scherer (1962) distinguish between two types of uncertainty: internal and external. Internal uncertainty may stem from a variety of sources, including the use of immature technologies or the need to make changes as the design matures. Generally, the DoD attributes internal uncertainty to changes in the following categories.

- **Economic**

  Projected price growth changes.
- **Quantity**

  Adjustments are made to the quantity of units procured.
- **Schedule**

  Delivery schedules, production completion dates, or production milestones are revised.
- **Engineering**

  Physical or functional characteristics of the program are altered to meet changing requirements.
- **Estimating**

  Errors in preparing the original estimate are corrected, previous estimates are refined, or cost-estimating assumptions change.
- **Support**

  The type or extent of training, including the training equipment, is updated to reflect changing requirements or mission needs.

External uncertainty, on the other hand, "involves changes in the demand for a weapon due to changes in the external threat, changes in the availability of substitute weapons, or simply changes in Congress's willingness to purchase certain weapons" (Rogerson, 1994, p. 67). Cost-reimbursement contracts are best suited when there are high levels of internal and external uncertainty.

Because many of the DoD's systems are technologically complex and, in some cases, unprecedented (i.e., there are no prior examples on which to base development), requirements, technology, quality dimensions, and performance specifications often evolve over time. Indeed, the GAO (2010) has concluded that most weapons programs proceed with limited knowledge on technology, design, and manufacturing in the acquisition process. As one might expect, it can also be difficult to verify whether or not the contractor has fulfilled its obligations, given the necessarily broad language contained in the contract. In short, incomplete information results in higher risk. When making

contractual arrangements, the high uncertainty and complexity associated with MDAPs should be taken into account.

Components of the Fixed-Price Contract

"Firm" fixed-price contracts are rarely used in conjunction with major development programs. Rather, many DoD programs are governed by fixed-price-incentive contracts. According to the FAR, a fixed-price incentive contract provides for adjusting profit and establishes the final contract price "by application of a formula based on the relationship of total final negotiated cost to total target cost" (FAR 16.403). The final price is subject to a price ceiling, negotiated at the outset. The typical components of this type of contract are described as follows.

- **Target Cost**
  The initially negotiated figure for estimated contract costs and the point at which profit pivots.
- **Target Profit**
  The initially negotiated profit at the target cost.
- **Target Price**
  The target cost plus the target profit.
- **Ceiling Price**
  Stated as a percentage of the target cost. This is the maximum price the government expects to pay. Once this amount is reached, the contractor pays all remaining costs for the original work.
- **Share Ratio**
  The government/contractor sharing ratio for cost savings or cost overruns that will increase or decrease the actual profit. The government percentage is listed first, and the terms used are "government share" and "contractor share." For example, on an 80/20 share ratio, the government's share is 80% and the contractor's share is 20%.

- **Point of Total Assumption (PTA)**

  The point at which cost increases that exceed the target cost are no longer shared by the government, according to the share ratio. At this point, the contractor's profit is reduced one dollar for every additional dollar of cost. (Antonio, 2003).

A Brief History

Contracting for weapons systems can be characterized by a series of pendulum swings. At different points throughout history, DoD initiatives have promoted fixed-price contracts, sometimes to the exclusion of cost-reimbursement contracts, and vice versa. For example, in the 1950s, the DoD's heavy use of cost-reimbursement contracts resulted in significant cost growth, which led to the introduction of total package procurement (TPP), a strategy under which single fixed-price contracts were used to cover research, development, production, and support. TPP was conceived by the Air Force in the 1960s. Under TPP, "all anticipated development, production, and as much support as is feasible of a system throughout its anticipated life is to be procured as one total package and incorporated into one contract containing price and performance commitments at the outset of the acquisition phase of a system procurement" (Logistics Management Institute, 1967, p. 3). However, inaccurate cost estimates, based on overly optimistic technology assessments, led contractors to chronically underbid.

Contrary to popular belief, the contractor is not the only one to lose out in such situations. Often, by the time cost overruns are detected, the government has already invested large amounts in the program. If continued performance under a fixed-price contract drives the contractor to the verge of bankruptcy—which actually occurred twice during the 1970s—then the government risks having nothing to show for its investment. Moreover, given the significant defense industry consolidation that has occurred over the last few decades, reductions in the number of contractors could negatively impact competition among the remaining firms and jeopardize the overall health of the industry. In July 1971, the DoD changed its policy, asserting that

> It is not possible to determine the precise production cost of a new complex defense system before it is developed; therefore, such systems will not be procured using the total

> package procurement concept, or production options that are contractually priced in the development contract. Cost-type prime and subcontracts are preferred where substantial development effort is involved. (Acquisition of Major Defense Systems, 1975).

In 1988, Congress went further, passing Section 8118 of the Defense Appropriations Act, which prohibited the DoD from awarding fixed-price contracts in excess of $10 million for development of major systems or subsystems "unless the Under Secretary of Defense for Acquisition determines, in writing, that program risk has been reduced to the extent that realistic pricing can occur, and that the contract type permits an equitable adjustment and sensible allocation of program risk between the contracting parties" (Defense Appropriations Act for Fiscal Year 1988).

The early 2000s saw continued support for cost-reimbursement contracts. The Defense Federal Acquisition Regulation Supplement (DFARS, 2012) requires that the DoD avoid fixed-price contracts for development programs unless (1) the level of program risk permits realistic pricing and (2) the use of a fixed-price type contract permits an equitable and sensible allocation of program risk between the government and the contractor. The DFARS also clearly states that "for development efforts, particularly for major defense systems, the preferred contract type is cost reimbursement."

In recent years, the DoD has used cost-reimbursement contracts more than any other department. According to the Federal Procurement Data System (FPDS), in 2008, cost-reimbursement contracts for defense systems and research amounted to $17.5 billion. Because cost-reimbursement contracts generally include an award or incentive fee for the contractor based on its performance (i.e., delivering the product below the target cost), some government leaders have criticized the increasing use of this type of contract, asserting that it is a key contributing factor to large and frequent cost overruns. In its review of 92 federal government contracts, the GAO (2009b) concluded that cost-reimbursement contracts are often used without appropriate justification or sufficient government oversight. This criticism is not without merit; however, without incentive fees, there is often no other mechanism in place to encourage the contractor to prioritize cost efficiency in the development and delivery of the product. In fact, contractors face perverse incentives, such as placing low initial bids, to "get their foot in the door"; then,

once the contract is awarded, and costs increase, the government has little to no recourse. This is especially true if the cost increase is attributable to changes that the winning contractor has priced on a monopoly basis.

The Obama administration, for its part, believes that cost-reimbursement contracts are a major source of program cost growth. In 2009, the Obama administration launched a government contracting reform initiative. In a March 4 memorandum, President Obama (2009) asserted that excessive reliance by the federal agencies on cost-reimbursement contracts "creates a risk that taxpayer funds will be spent on contracts that are wasteful, inefficient, subject to misuse, or otherwise not well designed to serve the needs of the Federal Government or the interests of the American taxpayer" (p. 1) He also restated federal government policy: that "there shall be a preference for fixed-price type contracts" and that "cost-reimbursement contracts shall be used only when circumstances do not allow the agency to define its requirements sufficiently to allow for a fixed-price type contract" (p. 1) He also directed the Office of Management and Budget (OMB) to provide guidance to improve the acquisition process.

In response to the president's request, the OMB required federal agencies to reduce their dollar share of cost-reimbursement and other high-risk contracts by 10% (Orszag, 2009). These actions aimed to maximize incentives for successful contract performance. Combined with other initiatives to reduce reliance on contractors (e.g., "insourcing" previously contracted-out positions), overall federal contract spending declined for the first time since 1997. In the first half of 2010, the percentage of dollars awarded in new cost-reimbursement contracts dropped by 6% compared to the same time period in 2009.

III. Theoretical Basis

Agency theory, transaction cost theory (TCT), and incomplete contract theory provide a basis for understanding the advantages and disadvantages of cost-reimbursement and fixed-price contracts from the perspective of the contractor and the customer. We examine each of these theories in the following sections.

Agency Theory

Whenever one party (principal) depends on the action of another (agent) in a particular domain, a principal–agent relationship arises. With regard to contracting, this relationship is formed whenever one firm (the principal) hires another (the agent) to perform a service and then delegates some amount of decision-making authority to the agent. According to agency theory, it can be difficult to ensure that the agent acts effectively on behalf of the principal because (1) there is an inherent difference in the principal's and agent's interests (value conflict) and (2) it is difficult or expensive for the principal to monitor the agent's actions; as a result, the agent may have more insight into the real state of the work (information asymmetry).

The contract is the mechanism that governs the principle–agent relationship. Because the two parties do not share the same interests and values, agents may work below their capacity and even harm the principal's interest (moral hazard problem), even if the contract is specific and covers multiple contingencies. Agency theory focuses on developing an efficient contract to govern this relationship by overcoming the organizational differences in self-interest, risk aversion, and information asymmetry (Eisenhardt, 1989; Fama & Jensen, 1983; Ross, 1973).

Agency theory suggests that contracts can be structured so as to induce agents to serve the principal's interest; however, this entails higher agency costs, including the costs of investigating and selecting appropriate agents, gaining information to set standards, monitoring agents, bonding payments by agents, and taking on residual losses. In

addition to establishing the initial contract, minimizing these costs also presents a challenge.

Outcome-based contracts that align the interests of the agent with those of the principal can be effective in reducing the conflict of self-interest (Eisenhardt, 1989). For example, the DoD's increasing reliance on performance-based logistics (PBL) contracts is supported by agency theory. With PBL, the DoD contracts for outcomes, i.e., the contractor offers long-term support and maintenance services to achieve specified outcomes. Rather than purchasing individual support services (e.g., parts, repairs, engineering) via multiple, separate transactions, PBL strives for specific outcomes (such as the seamless availability of functioning weapons systems, communication devices, or vehicles). By incentivizing the contractor to achieve the required outcomes, the DoD objectives are aligned with those of the contractor. As a result, the contractor will be motivated to improve the reliability and durability of the supported system.

When it comes to selecting the contract type for a weapons system acquisition, agency theory helps to illuminate the challenges. With government contracting, there is a mismatch of interests and information. The DoD objective is national security while the contractors seek to maximize their profits. These differences in interests create the potential for an agency problem. The most critical issue is the flow of information: the DoD's personnel must have access to all of the required information when negotiating contracts with outside providers; however, when it comes to the long-term development of major systems, this is commonly not the case. Consequently, the use of a fixed-price contract, which should be used for low-risk acquisitions, is generally not appropriate.

Transaction Cost Theory

If agency theory argues against the use of fixed-price development contracts, TCT suggests that there are potential benefits associated with this contract type. A transaction cost is "any activity which is engaged in to satisfy each party to an exchange that the value given and received is in accord with his or her expectations" (Ouchi, 1980, p. 130). TCT asserts that transactions between individuals (or organizations) are not cost free. In

other words, there is a cost associated with participating in the market (i.e., making an economic exchange) beyond that which is reflected in the price of a good or service. This could be in the form of paying a commission when buying or selling a stock. TCT can also be applied with regard to everyday purchases. For instance, in deciding which winter coat to buy, one often compares prices at multiple retail outlets, expending time and energy in the process. In addition to these opportunity costs, the cost of traveling to different outlets is not insignificant. One might categorize these as "search and information costs," but other types of transaction costs, although less obvious, occur regularly in economic exchanges. Within the context of contracting, these costs include (1) the bargaining costs required to come to an agreement acceptable to both parties and (2) enforcement costs, which the customer pays to ensure that the contractor is meeting its obligations.

TCT has been widely used to analyze organizational behaviors, including government acquisition and contracting arrangements. Governments are growing increasingly aware of the importance of examining the transaction costs of certain activities in different contexts so that they can design governance mechanisms to minimize them. With regard to government contracting, because of the difference in organizational goals and interests, along with the inherent information asymmetry between contractor and buyer, contract negotiation and implementation are not cost free. In fact, the transaction cost of managing the relationship between government buyers and contractors from the bidding process to contract termination can be significant. Arranging the bidding process, initiating requests for proposals, negotiating with potential bidders, selecting potential contractors, and enforcing the terms of the contract all incur transaction costs. By using fixed-price contracts, the DoD can eliminate some of the transaction costs normally incurred after the contract is awarded. For example, under a cost-reimbursement contract arrangement, the DoD must determine what constitutes an allowable expense. Under a fixed-price contract, the costs associated with making such a determination are eliminated.

However, this advantage is less apparent if numerous changes are made to the fixed-price contract (since each change creates an additional transaction). As previously stated,

weapons programs are often initiated with incomplete information, and there are generally many changes driven by evolving technology and requirements.

And, because contractors may "bid low to win," the winning contractor has a perverse incentive to maximize the number of changes by, perhaps, suggesting a technology change that could improve performance, thus increasing the number of transaction costs for the fixed-price contract.

Incomplete Contract Theory

Creating a contract that is truly comprehensive is unrealistic; that is, few contracts can precisely define each party's obligations in all potential scenarios that may arise. Even when it is possible to do so, the transaction costs involved often make it impractical. Thus, instead of writing comprehensive contracts, parties often negotiate an incomplete contract, leaving some ambiguity in its provisions. As a result, the incomplete contract may contain contractual obligations that are observable to the parties involved "but not verifiable *ex post* by third parties, [such as] a judge or an arbitrator to whom parties might eventually refer when controversies arise" (Nicita & Pagano, 2005, p. 145). In this situation, the parties involved may exploit the ambiguities in the contract to their advantage. This possibility is of particular relevance with regard to defense programs that entail the development of highly specific assets. For instance, contractors may underinvest in asset specificity so that the product, or components of the product, might be "redeployed to alternative uses and by alternative users" at some point in the future (Nicita & Pagano, 2005, p. 146). However, the contractor also faces a risk. For instance, the DoD could claim, based on its interpretation of the contract, that a product does not meet the specified requirements, thereby nullifying the contract. Depending on the level of asset specificity, the contractor may be unable to put its investments to productive use.

The DoD, for its part, makes significant investments in contractor-performed research and development. Over time, the DoD may become dependent on a firm, especially if it is the sole provider of a certain technology. Even over the life of a single contract, the DoD may develop a dependency on a particular firm for a critical defense capability. In this

situation, there is a risk that the contractor will seek to renegotiate the contract, perhaps in order to increase its profits by exploiting ambiguities in the contract. The DoD may have little recourse, especially if it has already invested heavily with the contractor.

Broadly speaking, then, incomplete contract theory generally does not support the use of fixed-price contracts for weapons system development programs. Because initial performance requirements are often unstable, the ambiguity in the contract may enable the contractor to technically meet a requirement according to the letter of the contract (or its interpretation of the contract) but fail to meet its intent as envisioned by the DoD. Thus, because the contractor does not necessarily hold the same interests as its customer, programs may fail to meet DoD expectations.

IV. Fixed-Price Contracting in Practice

In this section, we examine three DoD aircraft acquisitions that relied on fixed-price contracts: the C-5 Galaxy, the F-111 Aardvark, and the A-12 Avenger II. These examples were chosen to highlight the various risks associated with fixed-price contracting. We then provide a brief overview of the F-117 Nighthawk program, which used a cost-reimbursement contract during the development phase, in order to illustrate the positive outcomes that were obtained.

The C-5 Galaxy

Conceived in the early 1960s to augment the U.S military's airlift capability, the C-5 Galaxy ("C-5") is among the largest military aircraft ever produced. The C-5 has been used in virtually every U.S. conflict from Vietnam to Iraq. Today's updated C-5s can carry more than 920,000 pounds of equipment (which could include up to six Boeing AH-64 Apaches or five Bradley Fighting Vehicles; see Table 2). Griffin (2004) notes that the C-5 "still accomplishes tasks that no other military aircraft, such as the new C-17 or any derivative of commercial cargo aircraft, can perform and has consistently carried more cargo than any other aircraft in the time of war" (p. vi).

The C-5 has a number of unique features. For example, the nose swings open on hinges so that in addition to an aft ramp, a front ramp can be extended for easy loading and unloading of equipment. Another innovation is an automated built-in test capability that "electronically monitors 600 test points, locates any troubles, and prints out repair instructions" (Shults, 1976, p. 4). The initial aircraft specifications, however, also called

for a number of innovative features that in retrospect were a clear case of over-specification by the Air Force, commonly referred to as *gold-plating*. For example, included in the original requirements document was the requirement for an in-flight airdrop capability—the design would have to be able to airdrop single loads of up to 50,000 pounds from the rear cargo bay. There was also a requirement for advanced avionics that would allow the C-5 crews to identify drop zones and conduct airdrop operations at night or in poor weather. Further, there was a requirement for a terrain-following radar so that the C-5 could fly at low altitudes to evade detection by the enemy (Shults, 1976). Additionally, there was a requirement for the C-5 to be capable of landing on short, unimproved runways. Early criticism surrounding the inclusion of these features—many believed that they would never actually be used—was, for the most part, initially overlooked. As it turned out, including these capabilities proved technically challenging and, ultimately, very costly to develop.

Weight Capability	
Design Weight	764,000 pounds (1) 840,000 pounds (2) 920,000 pounds (3)
Max payload	265,000 pounds (4)
Max fuel	335,000 pounds
Max landing weight	635,850 pounds
Performance Capability	
Cruise performance	440 knots at 30,000 feet
Airport performance Takeoff Landing	 8,000 feet at maximum gross weight 4,000 feet with 100,000 pounds cargo
(1) at 2.25 g (2) with new wings (1980-1987) (3) in flight limit after refueling (4) with new wings (1980-1987)	

Table 2. C-5A Performance Characteristics
(Launius & Dvorscak, 2001)

In an effort to incentivize contractors to minimize program costs, Secretary of Defense Robert McNamara introduced TPP in the mid-1960s to acquire the C-5. As its name suggests, TPP incorporates into a single contract all development and production (and, often, support) costs. In addition, the contract would include precise price and

performance expectations. The C-5 contract was negotiated, using this strategy, with a fixed-price incentive contract (Shults, 1976). Under this type of contract, contractors could receive increased profits if the price came in below the agreed-upon initial estimate. Assistant Secretary of the Air Force for Installations and Logistics Robert Charles justified its use, asserting that

> a fixed-price incentive contract is the most feasible type of award to be issued under the total package procurement plan. A straight fixed-price contract may apply to some areas where nothing more than routine engineering and production are involved, but where you're dealing with a system that hasn't been designed or developed when the contract is signed, the fixed-price incentive contract is best. Otherwise, you may be threatening corporate financial catastrophe, and that's the last thing we want. ("C-5A Pioneers in Subcontract Relations," 1967, p. 251)

However, there is little difference between a firm-fixed-price and fixed-price incentive contract when it comes to averting "corporate financial catastrophe." Under either arrangement, the contractor has little to no recourse should costs exceed the agreed-upon ceiling price. This would become painfully clear as the C-5 program progressed.

In December 1964, the DoD initiated the C-5A program and issued a request for proposal (see Table 3) Four months later, in April 1965, three firms submitted their bids for the 10-year, 115-airplane contract: Boeing, Douglas, and Lockheed. Boeing's bid was the highest at $2.2 billion, followed by Douglas's at $2 billion (Shults, 1976). Lockheed submitted the lowest bid at $1.9 billion. Lockheed's low bid was unsurprising given its financial position at the time. Unlike its two competitors, whose DoD contracts were balanced by commercial sales, Lockheed's business was almost completely dependent on the DoD (Shults, 1976). Moreover, Lockheed was in the final stage of its C-141 contract with the Air Force, and there were few other defense contracts on the horizon. However, there was speculation that the Air Force was interested in acquiring a supersonic transport aircraft at some point in the near future. In order to keep its production facilities operating and its manpower intact, Lockheed executives believed that securing the C-5 contract was essential.

Concept Exploration	1957–1963
Mission Effectiveness/Operational Analysis	1957–1963
Contractor Teams Assembled	1961–1963
Total Package Procurement C Evolution	1963–1965
AF System Program Office Cadre Established	1964
Systems Design and Development	1964–1972
Contractor Conceptual Design Trades	1961–1964
RFP Release	Dec 1964
Contractor submits proposal	20 April 1965
Contractor Proposal Evaluation by AF	April 1965–Sept 1965
Contractor Initial Debriefs	Sept 1965
Lockheed Announced as C-5 Winner	Sept 1965
Weight Growth/Drag Increase	Dec 1965–Jan 1967
System Program Office Cure Notice	Feb 1967
First SPO IRT	1967
First Fatigue Test Results	June 1968–Dec 1972
First Flight	28 June 1968
Defense Advisory Group	1969
ASC IRT	1969–1971
Flight Restrictions on C-5A	1969–1987
Production of C-5A	1967–1973
Last (81st) C-5A Delivered	May 1973
Initial Operational Capability	June 1970
New Wing Design Start	Jan 1976
First C-5A Wing Modification	June 1981
First C-5B Delivered	Sept 1985
Last C-5A Wing Modification	May 1987

Table 3. C-5 Timetable
(Griffin, 2004)

After a thorough evaluation, the Air Force's Source Selection Board chose Boeing, primarily based on the superiority of its design. However, top Air Force officials overruled the decision and chose Lockheed, contending that its bid represented significant savings to the government. General Electric and Pratt & Whitney were contracted by the Air Force to develop and manufacture the engines; however, Lockheed (having agreed to the engine specifications) was responsible for the delivery of the completed aircraft.

Lockheed's target cost for producing 115 C-5A airframes was $1.7686 billion. As stipulated by the contract, the Air Force was to pay Lockheed the target cost plus 10% profit ($177 million). Thus, the target price of the C-5A acquisition was set at $1.9453 billion (Shults, 1976). The Air Force also established a ceiling price of $2.2991 billion (130% of Lockheed's target cost). The Air Force recognized that Lockheed had assumed significant risk: responsibility over other contractors, the 10-year duration of the contract, and the unprecedented nature of the program—not to mention the low bid. These factors made it very difficult to envision all of the challenges that would arise, let alone meet them.

In an effort to reduce the financial risk to Lockheed, a number of clauses were built into the contract. For instance, the contract stipulated that Lockheed would pay only 30% of costs incurred that were over the target but below the ceiling price. However, in the event that costs exceeded the ceiling price, Lockheed would be solely responsible for covering them. On the other hand, as a fixed-price-incentive contract, if the total cost came in under the target price, Lockheed would be entitled to 50% of the savings. In addition, incentives were written into the contract to reward Lockheed for exceeding performance goals established by the Air Force. However, the failure to meet performance goals was not reflected in the form of penalties (as is often the case when contracting for large projects); rather, such failure would be viewed as a design deficiency that the contractor would be required to correct.

Delivery of the 115 aircraft was divided into two phases. The Air Force placed an initial order for 58 aircraft under the terms described in the initial contract. Upon their successful delivery, the Air Force would order the remaining 57, using a pricing formula that reflected the total cost of the first order. For instance, in the event that the cost of the first order exceeded the ceiling price by an amount up to 140.5% of the target cost, the percentage difference between the ceiling price and 140.5% would be multiplied by 1.5 (Shults, 1976). The target cost of the second order would be increased by the resulting percentage. If the total cost exceeded the ceiling price by more than 140.5%, this factor would be increased from 1.5 to 2. Some have argued that this clause, in particular, acted

as a perverse incentive. If costs of the first order began to increase for whatever reason, Lockheed might be incentivized to continue to incur costs up to just over 140.5%, at which point the second order of aircraft would be re-priced, thereby reducing the contractor's overall cost burden by significantly increasing the price of the second contract.

In 1968, the Air Force projected that the program might exceed initial estimates by more than $2 billion, of which approximately $1.06 billion was attributable to Lockheed (see Table 4). The remainder of the overrun was attributed to General Electric for increases in the cost of its engines and to the Air Force for logistics-related cost increases. Lockheed's overruns stemmed primarily from its efforts to correct design deficiencies that were discovered during the initial testing. For example, stress tests produced small cracks in the wing spars. The contract required that the C-5 withstand stresses of up to 150% of limit load. The cracks appeared under stresses of 128% of limit load. To solve the problem, Lockheed replaced the titanium fasteners with ones made of titanium, steel, and aluminum. This added approximately $185,000 and 250 lbs. to each aircraft, but the problem was only partially solved. As a result, the C-5 could only carry 80% of the required payload. In addition, based on this design change, the aircraft's life expectancy was reduced from 30,000 hours to 20,000 hours (Shults, 1976).

	Target Cost Contract Award October 1, 1965	Lockheed Estimate September 30, 1968	Difference
Engineering	$286,542	$416,242	$129,700
Tooling	$158,908	$236,372	$77,464
Production	$509,527	$1,121,967	$612,550
Subcontracts	$245,527	$424,948	$179,421
Quality Assurance	$30,282	$54,447	$24,165
Other	$47,927	$81,516	$33,589
Total	$1,278,603	$2,335,492	$1,056,889

Table 4. Contractor's Cost for RDT&E and First Order (In Thousands of Dollars) (GAO, 1969)

Many other problems were discovered throughout the testing process. For instance, the wing surface had to be enlarged to reduce drag. This was a relatively cheap fix, but as a result of the modification, the aircraft exceeded the contractual weight limit. The design of the engine mounts was also inadequate, as vividly demonstrated in 1971 when an engine fell off the aircraft during take-off. Other deficiencies included the landing gear, which was designed to "kneel" to facilitate rapid loading and unloading. The process took 12 minutes; however, the contract specified that it take no longer than three minutes. In addition, the terrain-following radar never worked properly; the aircraft was never able to land on unimproved runways (early attempts caused severe damage to the engines); and the cargo door could not be opened during flight, which meant that the airdrop requirement, discussed previously, could not be met. Other factors, although minor in comparison, led to additional increases. For instance, Lockheed underestimated the labor and material costs, which rose steadily during the early years of the program. In addition, Lockheed implemented a new management structure, requiring that all program areas report their problems to the directorate level. This structure, it was believed, led to further inefficiencies and cost increases.

Indeed, many of the so-called deficiencies could be better described as "under capabilities." This is not to say that there were not serious design problems, especially with regard to the wings, but that certain features (e.g. the special landing gear, airdrop capability, and terrain-following radar) could have been forfeited early on to the benefit of all parties involved, especially since these features were seen by many as nice-to-have, not need-to-have features. But under TPP, Lockheed was contractually obligated to fulfill all performance requirements. As a result, Lockheed spent an inordinate amount of time, effort, and money engaged in futile efforts to correct deficiencies—time and money that could have been saved had there been the ability to more easily negotiate performance trade-offs. In 1968, for instance, Lockheed asked the Air Force to relax the aircraft weight ceiling (Shults, 1976). The Air Force denied the request. Lockheed then proposed a trade-off: relaxing the weight ceiling in exchange for increased thrust. The Air Force refused this proposal as well. The Air Force maintained that because the contractor signed the initial contract, it had to meet all requirements without exception or

modification. As a result, Lockheed had to use uncommon materials to reduce the weight, which led to spiraling costs.

There is some indication that the Air Force may have attempted to conceal the overruns from Congress. For instance, in early 1967, when the program office was first made aware of aircraft deficiencies, it issued a "cure notice," which notified Lockheed that unless the deficiencies were resolved, the contract would be terminated. The Air Force later rescinded the notice but launched an internal investigation into the nature of the deficiencies as well as their cost implications. The findings were never made public. Moreover, when the Air Force's investigation revealed a projected $2 billion overrun, the Air Force failed to immediately inform Congress. A debate ensued over whether the Air Force failed to follow the required notification procedures. The Air Force, for its part, contended that it was not obligated to disclose cost estimates between official congressional testimonies.

In late 1968, the Air Force realized that Lockheed was on the verge of bankruptcy. In 1969, realizing that it would have little recourse should Lockheed's situation worsen, the Air Force took delivery of the first C-5A, leaving many of the acknowledged deficiencies unresolved. In fact, it was not until 1987 that all of the C-5As received new wings, allowing the aircraft to carry the initially-required maximum payload. Even after the Air Force signed off on the initial order, it was unclear if Lockheed would be able to sustain its operations. However, after several rounds of negotiation, the Air Force decided that it would pursue the acquisition of the remaining 57 aircraft under the conditions of the original contract. But because Lockheed exceeded the 140% threshold discussed previously, the second order was re-priced. However, this course of action was short-lived. Later that same year, the Air Force reduced its second order from 57 to 23 (for a total of 81 aircraft) on account of the aircraft's increased price, suboptimal performance, and other budgetary pressures (Shults, 1976).

As a result, Lockheed's financial position worsened considerably, prompting the firm to seek assistance from the government. In 1971, the Air Force replaced the existing contract with a cost-minus-fixed-fee contract, under the condition that Lockheed absorb a

$200 million loss, which was more than half of the firm's net worth. Lockheed agreed, production resumed, and the 81st C-5A was delivered in 1973. The Nixon administration later provided a $250 million federal loan to Lockheed in order to preserve Lockheed's defense production capacity and protect the more than 25,000 jobs that would be lost if Lockheed were to declare bankruptcy. The Air Force, for its part, acknowledged that TPP was a flawed approach and that it would return to more traditional strategies.

The F-111 Aardvark

The F-111 Aardvark ("F-111") was a multipurpose tactical fighter-bomber capable of supersonic speeds. A unique feature of the F-111 was its variable sweep-wing, which pivoted back for high-speed flight and pivoted forward for a short takeoff and landing. Another unique feature was the crew compartment, which, in the event of an emergency, would serve as an escape module for the two-man crew.[4] Despite its controversial origins and costly procurement, the F-111 turned out to be one of the most effective all-weather interdiction aircraft ever built. At the time, no other aircraft in the Air Force could carry out the F-111's mission, which included precise, long-distance air strikes in all-weather conditions.

The history of the F-111 program dates back to the late 1950s. The Air Force was considering replacing a number of its ageing fighters (the F-100, F-101, and F-105). At the same time, the Navy was assessing its options for a two-seat, carrier-based, fleet air defense fighter to replace its F-4 and F-8. Although their needs differed considerably,

[4] The escape module would fall to the ground, under a parachute, with the two crewmembers strapped inside.

Secretary McNamara insisted that the Navy and Air Force work together to develop joint requirements to the extent possible. In February 1961, Secretary McNamara directed the development of a single aircraft that would satisfy both the Air Force's and Navy's requirements, believing that this strategy would substantially reduce acquisition costs. The project was known as the Tactical Fighter Experimental (TFX; see Figure 2).

Armament: One 20mm M61A1 gun, plus a mix of up to 24 conventional or nuclear weapons
Engines: Two Pratt & Whitney TF30-P-3 of 18,500 lbs. thrust each (with afterburner)
Maximum speed: 1,452 mph
Cruising speed: 685 mph
Range: 3,632 miles
Service ceiling: 57,000 ft.
Span: 32 ft. swept; 63 ft. extended
Length: 73 ft. 6 in.
Height: 17 ft.
Weight: 92,657 lbs. maximum
Crew: Two

Figure 2. F-111A Technical Specifications
(GAO, 1973)

In September 1961, the DoD issued an RFP. The Air Force version of the TFX was designated as F-111A, the Navy version as F-111B. Rather than producing actual hardware, competing contractors built models that were then subjected to wind tunnel testing. The GAO (1970) asserted that this resulted in a "paper competition," with contractors submitting unrealistic cost estimates. Indeed, cost growth occurred shortly after the contractor was chosen. More problematic still, the DoD pursued concurrent development and production of the F-111. In other words, the DoD guaranteed that the selected contractor would be paid to both develop and produce the aircraft, which, it has been argued, served as a disincentive to efficient development.

Boeing and General Dynamics were invited to participate in the final competition in September 1962. Both the Air Force and the Navy preferred Boeing's designs. However, in November 1962, the Office of the Secretary of Defense selected the General Dynamics design, believing it would lead to a greater degree of commonality between the Air Force

and the Navy variants and, thus, to lower costs (Boeing's two versions shared less than half of the major structural components). According to the two designs, the F-111A and F-111B would share the same primary structure, the same fuel system, the same pair of turbofans, and the same two-seat cockpit.

An initial fixed-price-incentive-contract was awarded to General Dynamics. The R&D contract was approved in 1964, with a target price of $480.4 million, and included the production of 23 test aircrafts (18 Air Force and 5 Navy). Three production contracts were issued over the course of six years, beginning in 1965. The initial target price for production of all 1,196 F-111s was estimated at $2.067 billion. Despite Secretary McNamara's proclamation that the development and production of a common aircraft would save as much as a billion dollars, costs increased dramatically over the duration of the program. By 1972, the development cost estimate more than tripled, to $1.675 billion, while the production estimate increased by more than $3 billion, to $5.334 billion. Note, however, that these figures did not take into account the cost of the government-furnished engines, which were built by Pratt & Whitney.

The early development of the F-111 proved problematic and costly. Problems included inlet-engine compatibility, structural failures in the wing carry-through structure, and the introduction of a technically immature digital avionics system. The effort expended to develop and produce the aircraft based on firm requirements, many of which were unrealistic, led to pronounced variances between original requirements and the actual performance. The Air Force attributed these variances to higher than anticipated fuel consumption, aerodynamic drag, and increased weight. Early testing uncovered the following variances:

- a decrease of 86% in the specified "dash" distance at supersonic speed,
- a decrease of 34% in specified ferry range,
- an increase of 37% in takeoff distance, and
- an improvement of 42% in navigational accuracy (GAO, 1970).

In 1963, the Air Force estimated the unit cost of the F-111A to be $3.97 million, but by 1972, the unit cost increased to $15.01 million. Table 5 illustrates the changes in unit cost.

	1963 Estimate	June 1969	June 1970	June 1971	June 1972
Development Cost	863	1630.1	1,628.5	1,641.5	1,641.5
Procurement/Construction Cost	4,642.5	5,771.2	4,751.9	5,026.4	5,353.1
Additional Procurement Cost			960.3	903.4	511.4
Total Dollars	5,505.5	7,401.3	7,341.1	7,571.3	7,506
Program Unit Cost	3.97	12.52	14.05	15.09	15.01
Quantity	1,388	591	454	442	466

Table 5. Changes in Cost of F-111 (In Millions of Dollars)
(GAO, 1973)

According to the GAO (1970), the increases in unit cost can be attributed to the following factors:

- a decrease in the number of aircraft to be produced,
- an increase in the number of aircraft versions (including those later abandoned),
- weapons systems capability improvements,
- inflation, and
- technical problems.
- More generally, the joint effort proved problematic. According to Elmer Staats, the comptroller general at the time, "Program costs were undoubtedly increased by the effort to procure an aircraft with a high degree of commonality to serve the needs of both the Air Force and the Navy" (*Statement by Elmer B. Staats*, 1971, p. 3). According to the Federation of American Scientists, "this was impossible to achieve, especially since planners placed priority upon the Air Force requirement, and then tried to tailor this heavy landplane to the constraints of carrier-based naval operations" (2011, p. 1) Staats notes, for example, that the Navy was concerned about the increase in the aircraft's weight, a concern that was not

shared by the Air Force. Efforts to resolve the differences in opinion and settle on a weight limit clearly delayed production of the aircraft. Indeed, the program experienced many significant schedule slippages. The initial delivery schedule incorporated into the definitized production contract showed that a total of 449 aircrafts were to be delivered by December 31, 1969, but as of that date, only 207 had been delivered. Other schedule changes included the following:

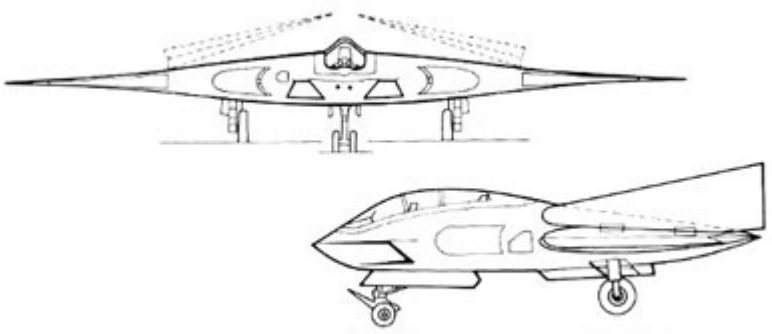
- The start of Category I flight tests for the F-111D slipped 14 months.
- The start of Category II flight tests for the F-111D were expected to slip 20 months.
- The delivery of the first production of the MARK II avionics system for the F-111D was expected to slip 20 months. (GAO, 1970).

The first flight of the F-111A took place in December 1964, and the first production models were delivered to the Air Force in 1967. Meanwhile, the F-111B program was canceled because it was not meeting the Navy's expectations. According to the Navy, of the $335 million it spent, $115 million was considered a "lost cost" (Staats, 1971). Production ended in 1976. In all, 562 F-111s of all series were built, 159 of which were preproduction and production F-111As. The Air Force aircraft was later produced in a variety of models, including the F-111A, F-111D, F-111E, and F-111F, as well as the FB-111A strategic bomber.

The A-12 Avenger II

The 1980s introduced the age of stealth. During this time period, the Air Force deployed the F-117 stealth fighter and was developing the B-2 stealth bomber. The Navy believed that it also needed to take advantage of the emerging technology. The result was the A-12 Avenger II ("A-12"), an all-weather, carrier-based stealth bomber that would replace the Grumman A-6 Intruder.

The Navy began its Advanced Tactical Aircraft (ATA) program in 1983 (see Figure 3). One of the program's objectives was to incorporate advanced stealth technology into the development of medium-attack aircraft with long ranges, high payloads, and a very low visibility profile. Another objective was to design an aircraft that could remain undetected outside a 10-mile radius of a radar.



Specifications
Crew: 2
Length: 37 ft. 10 in
Wingspan Unfolded: 70 ft. 3 in
Folded: 36 ft. 3 in
Height: 11 ft. 3 in
Wing area: 1,308 ft²
Empty weight: 39,000 lb.
Loaded weight: 80,000 lb.
Powerplant: 2× General Electric F412-GE-D5F2 non-afterburning turbofans, 13,000 lbf. each

Performance
Maximum speed: 580 mph
Range: 920 mi
Service ceiling: 40,000 ft.
Rate of climb: 5000 ft./min
Wing loading: 61 lb./ft²
Thrust/weight: 0.325

Figure 3. Specifications for A-12 Avenger II
(Richardson, 2001)

On January 13, 1988, a team consisting of General Dynamics and McDonnell Douglas was awarded a full-scale development contract. The contract was a fixed-price-incentive-contract with a target price of $4.38 billion, a ceiling price of $4.784 billion, and a 60/40 share ratio between target and ceiling with an economic price adjustment (to account for inflation). In an effort to reduce the financial risk to the contractor team, the contract stipulated that the Navy would pay 60% of costs incurred that were over the target cost but below the ceiling price. The target price included $3.98 billion in costs, with a possible profit of $398 million (10% of the target price). The contractor agreed to develop and deliver eight fight-test aircraft and five full-scale ground test articles (DoD, 1991). The Navy initially planned to buy 620 A-12s, and the Marine Corps planned to purchase an additional 238 planes. The Air Force also considered buying 400 A-12s to replace its F/B-111 and F-15E (GAO, 1991a).

From the beginning, the development process was troubled by a series of significant technical and engineering problems. First, there were several conflicts in conceptual design. The Navy wanted the A-12 to be a carrier-based “superplane” that could survive the rigors of carrier landing at sea and also evade radars. These two requirements were in conflict, given the technology level at that time: the harsh landing, ocean spray, and sun damaged the plane's finish, making it less able to evade radars (GAO, 1991b).

Second, the extensive use of composites in the A-12 structure, to minimize stress, led to technical difficulties with the structure and increased costs. These composites exceeded the anticipated weight. As a result, heavier metal components had to be used for some structural elements. Thus, the final weight of each aircraft exceeded 30 tons and was between 10% and 30% over design specification (Mahnken, 2008). This was a serious concern for carrier-based operations. Unfortunately, the McDonnell Douglas and General Dynamics team had limited experience in building large structures using composites. To solve this problem, the team had to develop this technology concurrently with the full-scale development of the aircraft.

Third, the contractor experienced technical difficulties developing the aircraft’s complex radar system (the Synthetic Aperture Radar System), which caused several delays.

Despite these technical difficulties, both the Navy and the contractor team were very optimistic about the schedule and cost of the A-12 program. On December 19, 1989, Secretary Cheney initiated a major aircraft review (MAR) to review four major aircraft programs, including the A-12. On April 26, 1990, Cheney, testifying before the House and Senate Armed Services Committees on the results of the MAR, confirmed the necessity of the A-12 development and the continuity of development efforts. He announced that the project was very likely to succeed under the current contract—the first A-12 would be delivered in early 1991, and the entire program would be finished within the original cost estimation.

However, in the early 1990s, as the development process evolved, McDonnell Douglas and General Dynamics revealed projected delays and cost increases. They admitted that the project faced serious engineering problems and some performance expectations could not be met. In response, the Navy agreed to postpone the first flight to December 1991. This new delivery schedule was established using a no-cost contract modification, with no increase in the ceiling price (U.S. Congress, 1992).

On July 9, 1990, the Secretary of the Navy conducted an administrative inquiry to investigate the problems associated with the A-12 development, with the focus on "the cause if the variance, accountability, and any systemic or other changes or improvements needed to ensure that significant information is developed and made available to appropriate officials in a timely, accurate manner" (Beach, 1990, p. 1) The results of the administrative inquiry, referred to as the Beach Report, concluded that the contractor team had limited experience building large composite structures and that the "projections of completion at or within ceiling were unrealistic, and not supported by the facts." It also indicated that the program manager in the Navy had "erred in judgment by failing to anticipate substantial additional cost increases beyond the ceiling … [and] greater risk to schedule" (Beach, 1990, p. 1). The inquiry concluded that the government and the contractor lacked the objectivity needed to properly assess program progress (Beach, 1990).

In August 1990, the contractor team requested the adaptation of flexible progress payments with a reimbursement rate of 97%, instead of the normal rate of 80%. Later, in October 1990, the Navy declined this request, arguing that the contactors failed to provide sufficient information to support the change. On November 12, 1990, the contractor team put forward an uncertified claim for equitable adjustment, asking for an increase of $1.47 billion over the previous target price, based on the delays and disruption experienced.

Secretary Cheney directed the Navy secretary "to show cause" as to why the DoD should not terminate the program (CRS, 1991). The Navy, in turn, required that the contractors respond to Cheney's demand and notified them that the contract might be terminated

unless satisfactory conditions were obtained by January 2, 1991. The contractor team submitted a new certified program claim, requesting a $1.4 billion increase in the target price. But on January 2, 1991, the contractor team replied that they could not meet the technical specifications and deliver the aircrafts in time.

On January 7, 1991, Secretary Cheney directed the Navy to terminate the A-12 program for default. The Navy believed that McDonnell Douglas and General Dynamics were not able to complete the design, development, and delivery of the A-12 while meeting the performance requirements within the schedule. Prior to the program's termination, the Navy had already paid the contractors $2.68 billion, but only a portion of that amount was for the items actually received (six design review products). Cheney issued the following statement:

> The A-12 I did terminate. It was not an easy decision to make because it's an important requirement that we're trying to fulfill. But no one could tell me how much the program was going to cost, even just through the full scale development phase, or when it would be available. And data that had been presented at one point a few months ago turned out to be invalid and inaccurate. ("Lifting the Veil of Military Secrecy," 1994)

It appears that the Navy never had an exact estimation of the real cost to complete the necessary research and development. In December 1990, the A-12 aircraft program office estimated the contract to cost $7.5 billion, plus an additional $0.9 billion for in-house work (DoD, 1991). However, the technical challenges were never taken into account in the formal cost estimation process. The Cost Analysis Improvement Group (CAIG) at the Office of the Secretary of Defense estimated the range of costs based on the percentage of completion of the research, development, test, and evaluation (RDT&E) phase of the program and the date of the first flight (see Table 6). The CAIG admitted that these estimations, although reasonable, were subject to changes, given that it had no technical knowledge of the various performance requirements (DoD, 1991).

Date of Flight	Percent of RDT&E Complete at 1st Flight		
	40	50	60
June 1992	$14,280	$11,424	$9,520
December 1992	156,865	12,692	10,577
March 1993	17,355	13,884	11,570

Table 6. A-12 Full-Scale Development Costs (In Millions of Dollars, Including Government Costs) (DoD, 1991)

In February 1991, the Navy required McDonnell Douglas and General Dynamics to repay $1.35 billion in progress payments. The contractor team believed that the manner in which the program was canceled was inappropriate and filed a lawsuit in U.S. Claims Court. It argued that the Navy breached the contract and that the termination was for the convenience of the government rather than for default.

This led to years of litigation between the contractors and the DoD over breach of contract. On June 1, 2009, the U.S. Court of Appeals for the Federal Circuit ruled that the U.S. Navy was justified in canceling the contract and that the two contractors should repay more than $1.35 billion, plus interest charges of $1.45 billion. However, the contractors vowed to appeal the decision. In September 2010, the Supreme Court declared that the government canceled the project in an improper manner and that the use of a state secrets claim by the U.S. government prevented the contractors from mounting an effective defense. More recently, in May 2011, the Supreme Court decision set aside the Appeals Court decision and sent it back to federal circuit court. The cancellation of the A-12 program was considered a major loss for McDonnell Douglas, which led to its eventual merger with its rival, Boeing, in 1997 (Boyne, 2002).

F-117 Nighthawk

In the 1970s, the Air Force expressed a desire to integrate stealth technology into its aircraft to enable the attack of enemy targets using the low-observable, radar-evading qualities. This led to the design and development of the F-117 Nighthawk ("F-117"), the first operational aircraft initially designed around stealth technology. The F-117 aircraft could penetrate enemy airspace without being detected. Thus, it brought new and impressive combat capabilities to the battlefield (see Figure 4).

The F-117 was developed within a Special Access Program; access to the program was strictly limited. It conducted its first flight on June 18, 1981, and achieved initial operating capability status in October 1983. However, only in November 1988 did the DoD acknowledge the existence of the F-117. The aircraft retired from the Air Force on April 22, 2008. By that time, a total of 64 F-117s had been produced, with five for testing and 59 for operational use.

In most regards, the F-117 program acquisition is considered a successful program. All of the key performance goals were achieved. The actual development schedule and total acquisition cost were comparable with those of contemporary programs. Its dramatically improved penetration capabilities were displayed in a broader range of operations in Panama, Iraq, Afghanistan, and Bosnia.

Armament: Up to 5,000 lbs. of assorted internal stores
Engines: Two General Electric F404-F1D2 engines of 10,600 lbs. thrust each
Crew: One
Maximum cruise speed: 684 mph
Range: Unlimited with aerial refueling
Ceiling: 45,000 ft.
Span: 43 ft. 4 in.
Length: 65 ft. 11 in.
Height: 12 ft. 5 in.
Weight: 52,500 lbs. maximum

Figure 4. **Technical Specifications of the F-117 NightHawk**
(Smith, Shulman, & Leonard, 1996)

The program began in 1974, when the Defense Advanced Research Projects Agency (DARPA) initiated "Project Harvey," a program requiring the design of an "experimental survivable testbed" aircraft. Lockheed's "Hopeless Diamond" design won the competition in April 1976. DARPA then issued a contract to Lockheed to build two test aircraft under the code name "Have Blue" in order to test the design's low observability.

The Have Blue testing occurred in December 1977 (see Figure 5). The test data were sufficiently encouraging that the DoD urged the Air Force to use stealth technology to develop an operational aircraft. The final decision to produce the F-117 was made on November 1, 1978. On November 16, 1978, Lockheed was awarded a contract for five full-scale development test aircrafts under the code name "Senior Trend."

The Senior Trend aircraft was a direct outgrowth of the Have Blue prototypes, incorporating many changes to turn the design into an operational combat aircraft. The aircraft was defined as a single-seat night strike-fighter with no on-board radar but with sophisticated navigation and attack systems and a variety of weapons. The F-117 had no air-to-air capability.

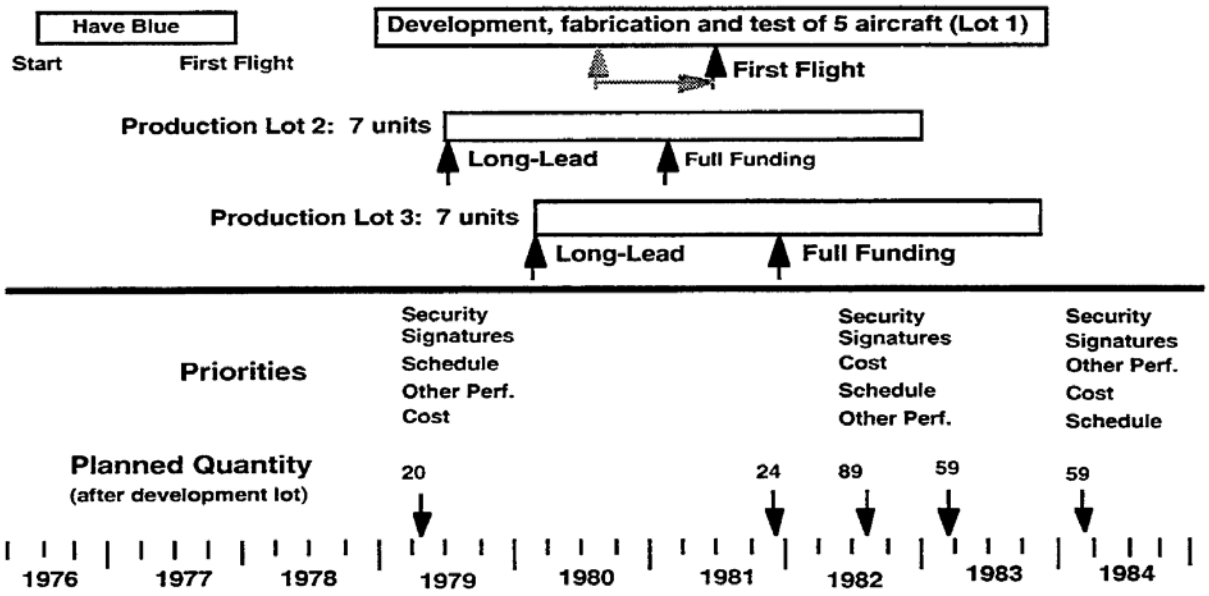


Figure 5. F-117 Program Development Schedule
(Smith, Shulman, & Leonard, 1996)

The Air Force adopted very flexible contract forms throughout the whole acquisition process. Table 7 provides an overview of the major contract structure. The initial development work, from the start of the program to the end of the formal engineering and manufacturing development (EMD) phase, was performed under a cost-plus-fixed-fee contract. This contract design gave both the Air Force and the contractor considerable flexibility in resolving problems identified during this phase. As is the case in many other development programs, even after the end of formal EMD, changes in the program were still necessary in order to achieve the desired capability and supportability. Further development work, which included a follow-on development program, was initiated under a fixed-price-incentive contract.

Production of operational aircraft was conducted in 10 lots. The first five lots, a total of 28 aircraft, were procured using FPI contracts, with each lot completed at a value close to the definitized price. The next five lots, the remaining 31 aircrafts, were produced under firm-fixed-price contracts.

Stage	Contract Type	Years Covered by Major Expenditures
Initial Development	Cost-plus-fixed-fee	1979–1983
Follow-on Development	Fixed-price incentive	1984–1990
Configuration Upgrades	Mixed	1984–1990
First 28 Production Units	Fixed-price incentive	1980–1984
Next 31 Production Units	Firm-fixed-price	1984–1989

Table 7. F-117 Contract Structure
(Smith, Shulman, & Leonard, 1996)

Program security restricted the number of officials involved in program oversight and limited the distribution of program documentation—in effect, streamlining the acquisition process. The system specifications were expressed in the form of contract goals, rather than hard requirements. Only three parameters were strictly required to meet minimum requirements: mission profile, ordnance loads, and takeoff and landing distance. This allowed program managers the flexibility of tailoring design decisions to overall program goals, rather than having to satisfy a large number of detailed performance specifications. Moreover, after the start of program development, no major changes were made in program performance requirements or other specifications (except for the change in total quantity). As a result, there was less need for system redesign and program restructuring, curbing cost growth.

Further, the strong and sustained support from the senior officials in the system program office (SPO) helped make the F-117 development progress smoothly. Mutual respect and good communications between the Air Force managers and the industry managers prompted resolution of issues. Trust in addition to tolerance for risks and uncertainty in program outcomes also guaranteed program stability.

Table 8 compares the actual costs of the program with the estimated costs. The actual F-117 development phase was somewhat less expensive than the estimation, and the production cost was slightly higher.

	Actual Costs	Estimated Costs
Total	$7,700	$7,900
EMD	2,500	3,000
Nonrecurring		1,390
Structures		790
Systems		440
Engines		140
Avionics		240
Production	5,200	4,900
Structures		2,400
Systems		1,340
Engines		420
Avionics		740
Note. EMD cost includes the cost of five flight test aircrafts. Production cost covers costs of the next 59 aircrafts produced.		

Table 8. Actual Costs Compared With Estimated Costs (In Millions of 1993 Dollars) (Smith, Shulman, & Leonard, 1996)

V. The Way Forward

In its effort to control cost growth, the DoD periodically embraces fixed-price contracts in order to shift more of the responsibility and risk to the contractor. However, based on the theoretical considerations and the examples presented in this report, we believe that fixed-price contracts are not well-suited to major development programs. Contrary to popular belief, the use of fixed-price contracts during system development may not eliminate, or even reduce, cost overruns; in fact, they can exacerbate them, especially when the technologies involved are immature or untested. With MDAPs, this is often the case; programs are characterized by technological unknowns, changing requirements, design instability, over-optimism, and production immaturity. This is not to say that, as a rule, fixed-price contracts should never be used in development programs but that their use will not correct, or compensate for, these systemic defense acquisition challenges.

Although the fixed-price contract holds political appeal for obvious reasons, the practical implications cannot be ignored. Time and again, fixed-price contracts have failed to facilitate the development and acquisition of complex military programs. In the case of the C-5, program cost overruns exceeded one billion dollars for the first time in military history. Moreover, the aircraft failed to meet numerous performance expectations. The A-12 program was initiated in 1984, only to be canceled seven years later after military leaders began to question its technical feasibility. Three decades later, the DoD continues to incur costs associated with the program, as litigation is still pending over the manner in which the program was canceled. As for the F-111, the fixed-price contract was unable to compensate for an ill-conceived plan to provide the Navy and Air Force with different versions of the same aircraft. Although intended to reduce costs, the strategy had the opposite effect.

Although these three examples are perhaps the most instructive with regard to the risks entailed in fixed-price contracting for development, there are a number of other examples.

- In 1991, government officials admitted that the C-17 Globemaster had exceeded initial cost estimates by over $3 billion dollars. Then Secretary of Defense Les Aspin fired the general in charge of the program. In its effort to salvage the program, the government decided to waive all potential financial claims against the contractor (McDonnell Douglas) for failure to meet contractual obligations, lowered the aircraft's performance standards, and ended up paying more for fewer aircraft.

- The V-22 Osprey tilt-rotor aircraft program incurred spectacular cost overruns. Initiated in the early 1980s, the original cost-reimbursement contract was later changed to a fixed-price incentive contract by Secretary of the Navy John Lehman in response to congressional pressure to control the costs of MDAPs. The contractor team, Bell-Boeing, felt that it had little choice but to accept the terms of the new contract because it had already made considerable investments. In 1986, the projected cost of the program was approximately $37 billion (in 2009 dollars) for 1,000 aircraft. By 2009, the cost had increased to $47 billion for 500 aircraft, a unit-cost increase of 48% (GAO, 2009c). Since the early days of the program, safety issues have been a perennial concern. Only recently, in 2005, was full production finally approved.

- Costs associated with the fixed-price development and acquisition of the Advanced Medium-Range Air-to-Air Missile (AMRAAM), begun in the late 1970s, more than doubled by 1984, from $3.4 billion for approximately 20,000 missiles to $8.2 billion for 24,335 missiles. As a result, the contractor, Hughes Aircraft, had to absorb $265 million in cost overruns (GAO, 1987).

Contractors may have an incentive to either underestimate or overestimate a program's costs depending on their interests. For example, to ensure against future uncertainty, the contractor may put forth a high cost estimate, especially in a non-competitive environment. On the other hand, in order to get a foot in the door, the contractor may substantially underbid a contract. In either case, information asymmetry, combined with

the general lack of knowledge associated with MDAPs, makes it difficult for the DoD to accurately assess the validity of contractors' estimates. Moreover, because of the high levels of internal and external uncertainty, unanticipated changes occur, which, in turn, lead to contract renegotiation, often with the DoD taking on increased risk and responsibility. In order to avoid the excessive transaction costs associated with contract renegotiation, the DoD should rely on cost-reimbursement contracts, which have greater built-in flexibility with regard to costs, schedule, and performance, allowing trade-offs to be made as development progresses. Of course, this contract type is associated with other challenges. For example, gold-plating, or a contractor's attempt to deliver a higher grade product than the customer needs or wants, tends to be associated with cost-reimbursement contracts. Of course, this problem cuts both ways. In the case of the C-5, the fixed-price contract included some extravagant features. Unable to meet some of the requirements, the contractor proposed a number of trade-offs that the Air Force, at least initially, refused to entertain. In these instances, one might argue that the contract actually constrained the development of the aircraft by shifting contractor efforts toward unattainable objectives.

It is also important to realize that contractors may have no intention of delivering the product at the target price specified in a fixed-price contract (especially if it was an initial low bid, in order to win the contract award). This is not an indictment against contractor ethics but merely recognition that considerable maneuverability exists within the contract. Depending on its interests, a contractor may set its own target profit—one that is lower than the target specified in the contract. It is important to remember that the contractor continues to make a profit (albeit a shrinking profit) until costs exceed the ceiling price. Perhaps the contractor believes that securing an initial contract will lead to more profitable opportunities in the future (e.g., the large number of "changes" that typically occur after the contract is awarded), or as we saw in the case of the C-5, the contractor wanted to keep production facilities operating for strategic reasons. In such instances, incentives that are built into the contract may not matter. Even if the contract contains a 50/50 share ratio and low ceiling price (e.g., 115% of the target cost)—conditions under which contractor profit drops precipitously upon exceeding the target

cost—there is no guarantee that this will improve contractor performance, especially if program requirements are technically unfeasible to begin with. In fact, when incentives to minimize costs are high, the contractor is more likely to insist on contract renegotiation in the event that unanticipated changes occur (Bajari & Tadelis, 2001). Often, the transaction costs associated with renegotiation erode the savings attributed to the use of high incentives.

Despite having copies of the same contract, the envisioned target profit, cost, and final price may vary considerably between the two parties. In theory, the distance between a target price and a price ceiling acts as a buffer to keep costs within a reasonable range. When the contractor envisions its own targets, that buffer may shrink considerably, thereby increasing the likelihood that costs will exceed the ceiling price.

At this moment, fixed-price contracts are being used for development efforts throughout the DoD. In February 2011, Boeing was awarded a fixed-price incentive contract to develop and build 179 new KC-46 strategic transport aircrafts at an estimated cost of $51.7 billion. The Air Force plans to exercise two contract options: the first for 19 initial production aircraft and the second for 18 mission-ready aircraft. Additional contract options can be exercised to allow for production of the remaining 156 aircraft through the year 2027 at a target rate of 15 aircraft per year. The initial contract specifies a target price of $4.4 billion and a ceiling price of $4.9 billion, with a 60/40 share ratio.

Air Force officials believed that the KC-46 development represented a relatively low-risk effort to integrate mature military technologies into a well-defined commercial derivative aircraft. However, the GAO (2012) recently asserted that the KC-46 development is suffering from multiple schedule and technical risks. For example, the testing schedule is not executable as planned. Although based on a commercial aircraft, the military version requires structural modifications, a fly-by-wire refueling system, and extensive software integration. After one year of development, the Air Force estimated that costs have increased to $900 million over the target price and about $400 million more than the ceiling price.

On the other hand, it is largely agreed that the F-117 Night Hawk, discussed in Section IV, was a model program. The F-117 was developed and produced on schedule and very close to within its budget. The program relied on a cost-reimbursement contract for development and a fixed-price incentive contract for low-rate initial production. Most important, the program illustrated the effectiveness of firm-fixed-price contracts when used for full-rate production, at which point the design is stable.

As the U.S. economy, still reeling from the recession of 2008, continues along the path to recovery, lawmakers are searching for ways to cut spending in order to reduce the country's $16 trillion debt. The DoD, which consumes the second largest portion of government revenue, after entitlements, will likely see significant cuts in coming years. Indeed, cuts are already being made. In August 2011, Congress reached a budget deal that will cut $350 billion in defense spending over the next 10 years. Sequestration threatens $600 billion more in cuts. At the same time, the United States is struggling to transform and modernize its military forces—and their business systems—in order to enhance national security. In light of these budgetary constraints and security challenges, the DoD will need to rethink how it uses its dwindling resources; in simple terms, it must be able to do more with less. What worked in the past may not work in the coming years. The DoD must initiate bold reforms to bring increasing costs under control. The historic back and forth over contract type has not brought the DoD any closer to acquiring weapons more affordably. Clearly, fixed-price contracts are not a cure-all. Rather, the DoD must rely more on proven acquisition practices—and less on shifting policies—in order to increase program knowledge, enhance stability, and reduce risk.

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In 2007, Dr. Gansler served as the chair of the secretary of the Army's Commission on Contracting and Program Management for Army Expeditionary Forces. He is a member of the Defense Science Board and the Government Accountability Office (GAO) Advisory Board. He is also a member of the National Academy of Engineering and a fellow of the National Academy of Public Administration. Additionally, he is the Glenn L. Martin Institute Fellow of Engineering at the A. James Clarke School of Engineering; an affiliate faculty member at the Robert H. Smith School of Business; and a senior fellow at the James MacGregor Burns Academy of Leadership (all at the University of Maryland). From 2003–2004, Dr. Gansler served as interim dean of the School of Public

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William Lucyshyn

William Lucyshyn is the director of research and a senior research scholar at the Center for Public Policy and Private Enterprise in the School of Public Policy at the University of Maryland. In this position, he directs research on critical policy issues related to the increasingly complex problems associated with improving public-sector management and operations and with how government works with private enterprise.

His current projects include modernizing government supply-chain management, identifying government sourcing and acquisition best practices, and analyzing Department of Defense business modernization and transformation. Previously, Mr. Lucyshyn served as a program manager and the principal technical advisor to the director of the Defense Advanced Research Projects Agency (DARPA) on the identification, selection, research, development, and prototype production of advanced technology projects.

Prior to joining DARPA, Mr. Lucyshyn completed a 25-year career in the U.S. Air Force. Mr. Lucyshyn received his bachelor's degree in engineering science from the City University of New York and earned his master's degree in nuclear engineering from the Air Force Institute of Technology. He has authored numerous reports, book chapters, and journal articles.

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Jiahuan Lu is a doctoral candidate of public administration at the Maryland School of Public Policy. His research interest focuses on public administration, government contracting, organization management, and performance management. He also works as a graduate research assistant at the Center for Public Policy and Private Enterprise in the School of Public Policy at the University of Maryland. In this position, he conducts research on defense contracting and acquisition reform.

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